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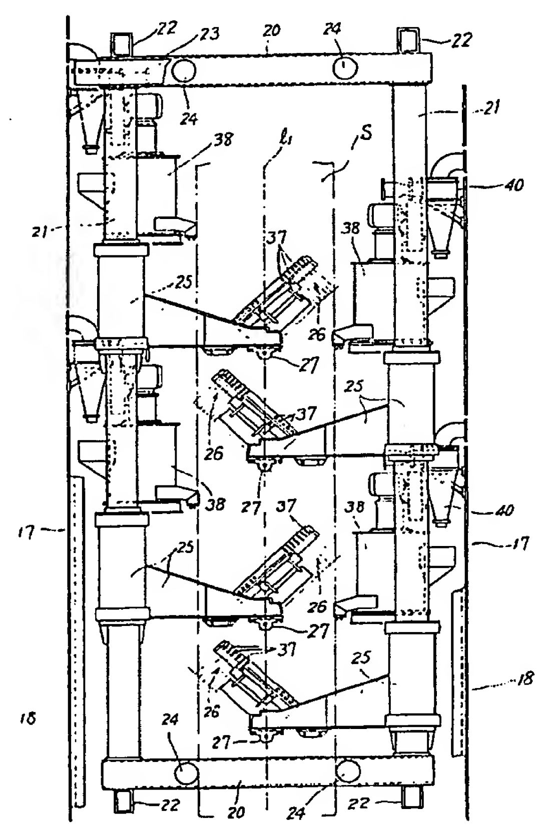
(54) A mechanical descaling device

(57) A mechanical descaling device having means (24) for guiding a sheet of metal (S) to be descaled past a plurality of nozzle assemblies (26) each comprising a line of nozzles (37) pivotable about one end on a pivot (27) the axis of which intersects the centreline of the sheet to be descaled passing through the device. Each assembly of nozzles (37) blasts a descaling slurry onto an area of the sheet extending from the centreline to a respective edge, and at least four assemblies are provided to cover all of both faces of the strip (S). The inclination of the nozzles (37) with respect to the strip (S) can be adjusted to suit different working conditions, and the whole assemblies can be tilted to accommodate different widths of sheet without missing any of the sheet (S) or leaving any area uncovered. Scale breaking means for rolling down the sheet under high pressur are located upstream of the nozzle assemblies (37).

Fig. 3



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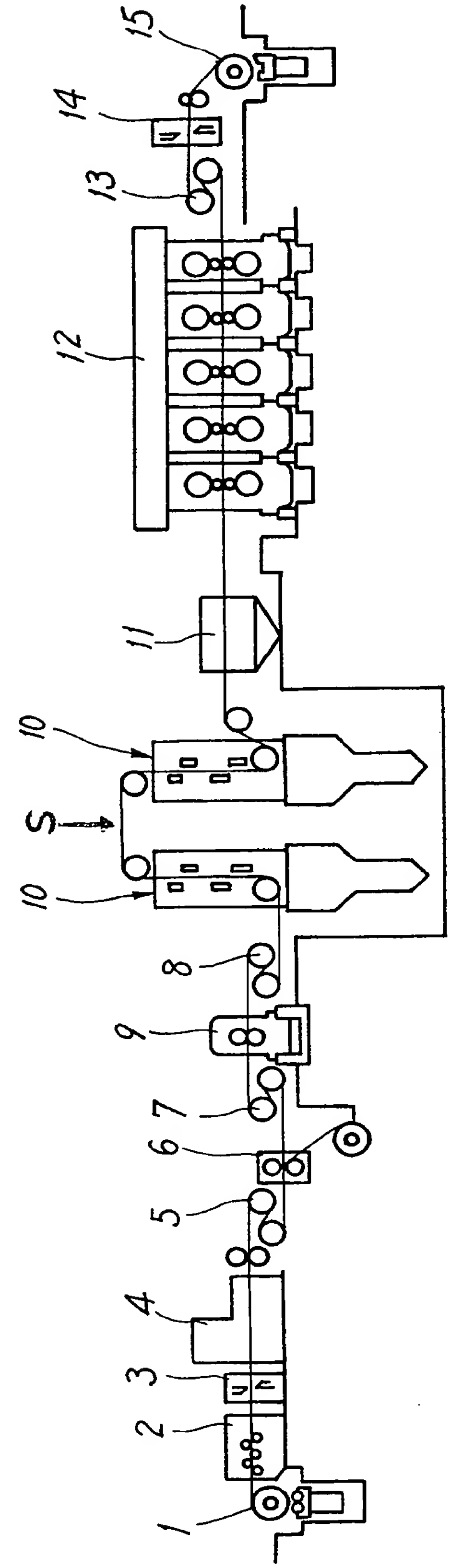


Fig. 1

Fig. 2

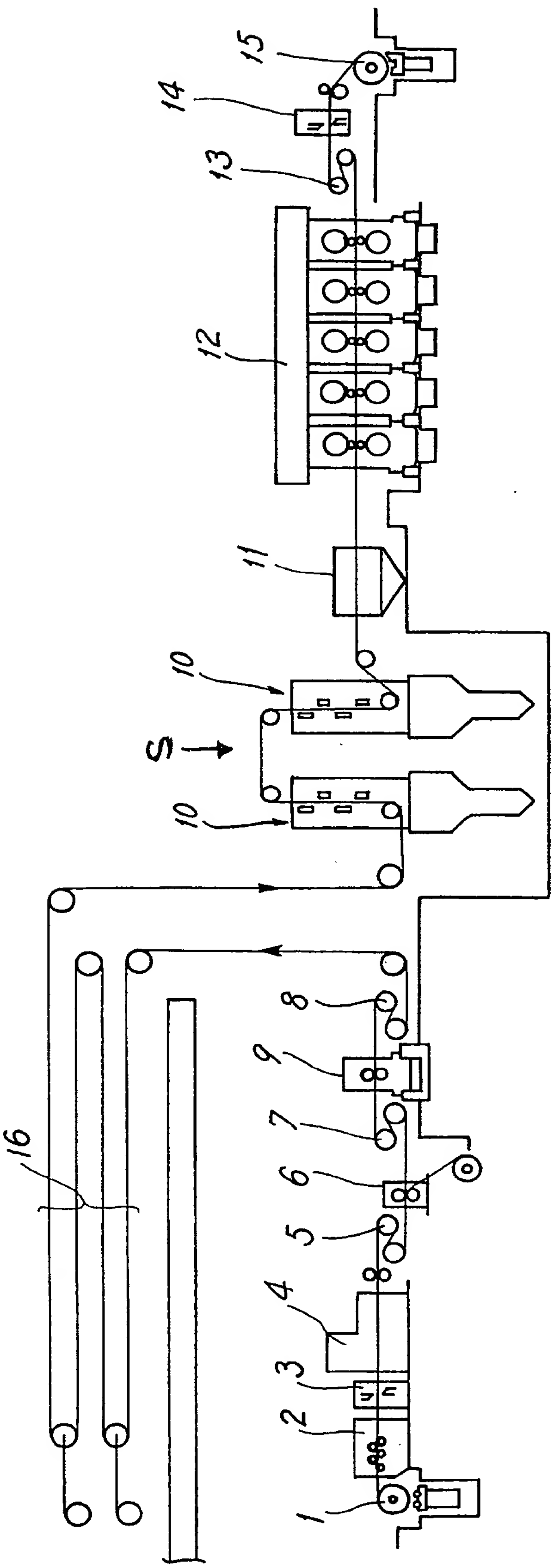
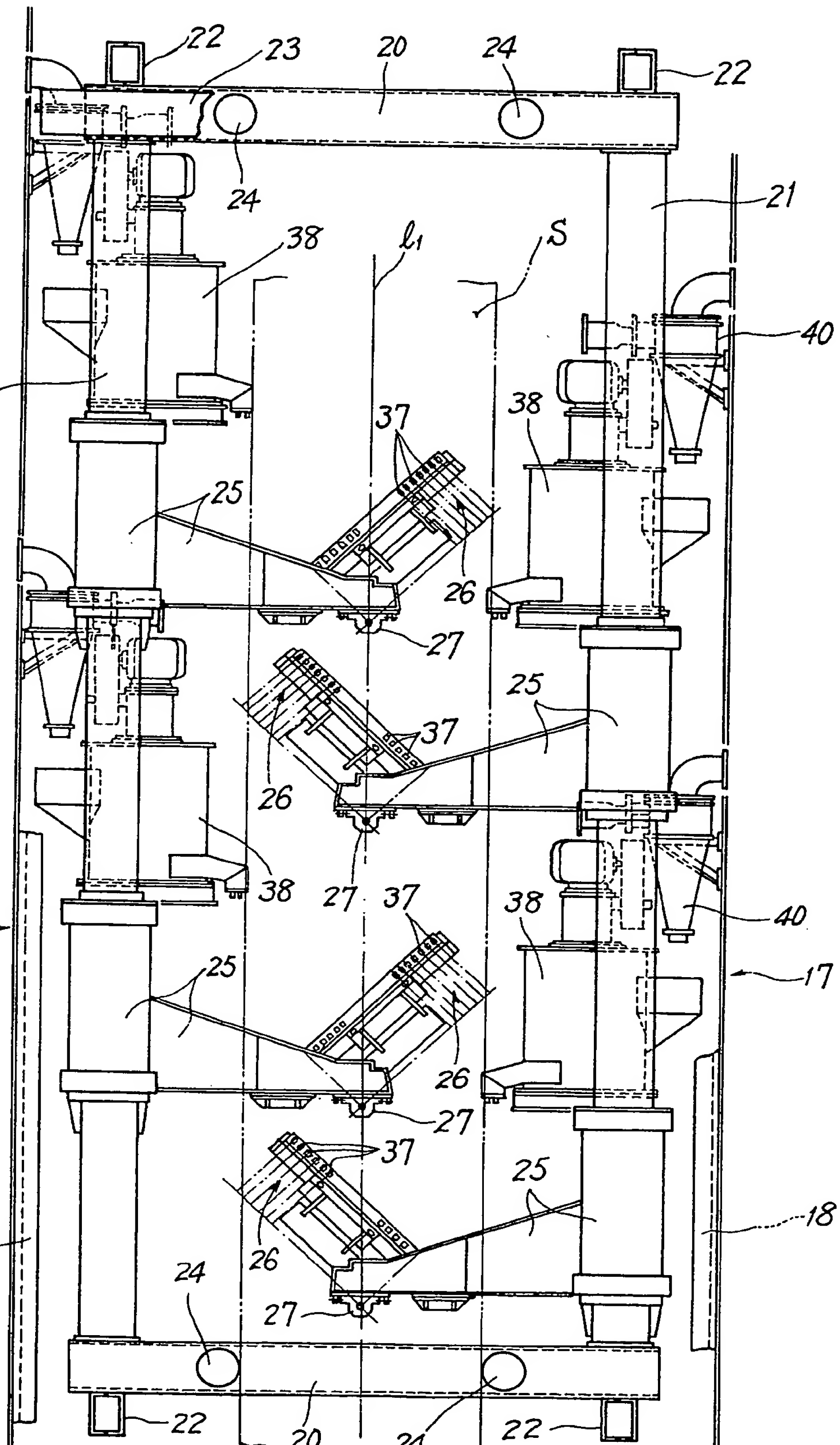


Fig. 3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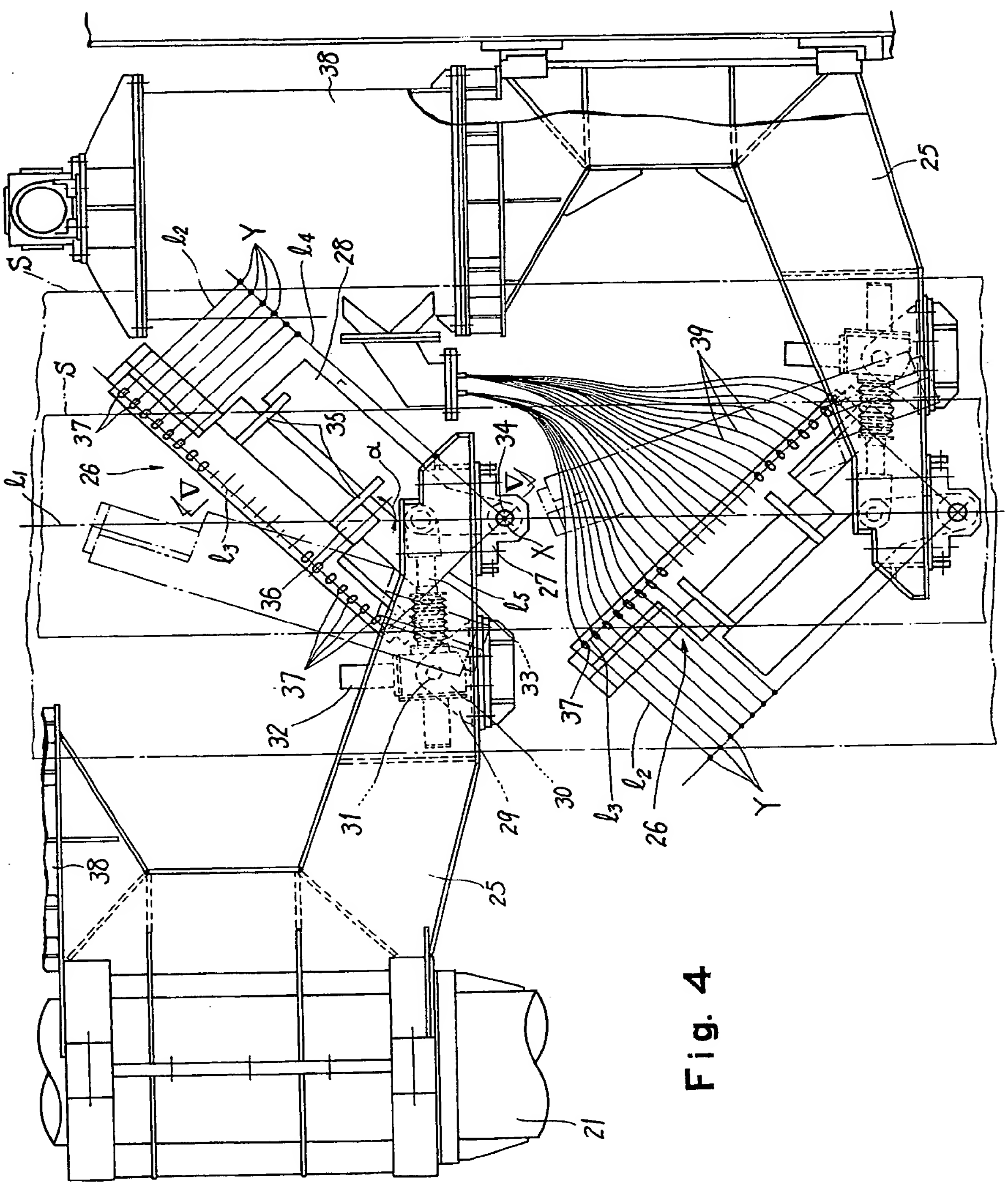

Fig. 4

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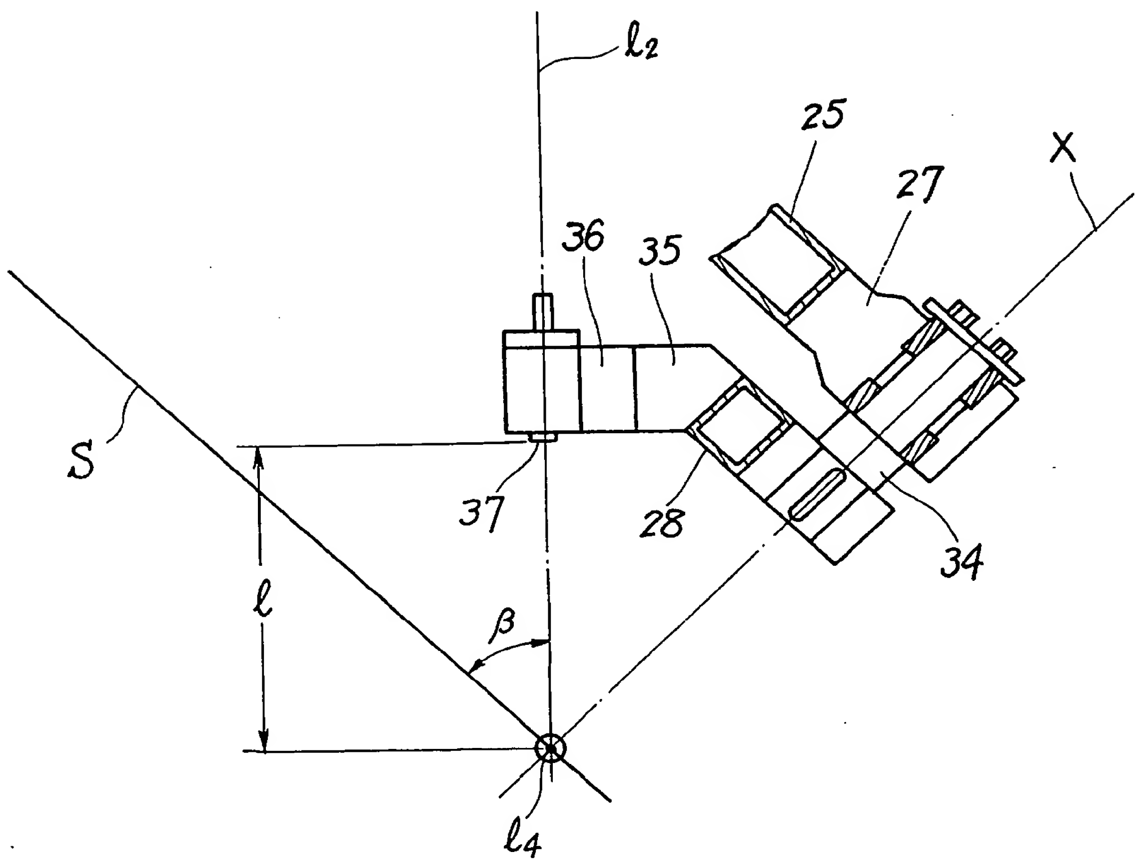
Fig. 5



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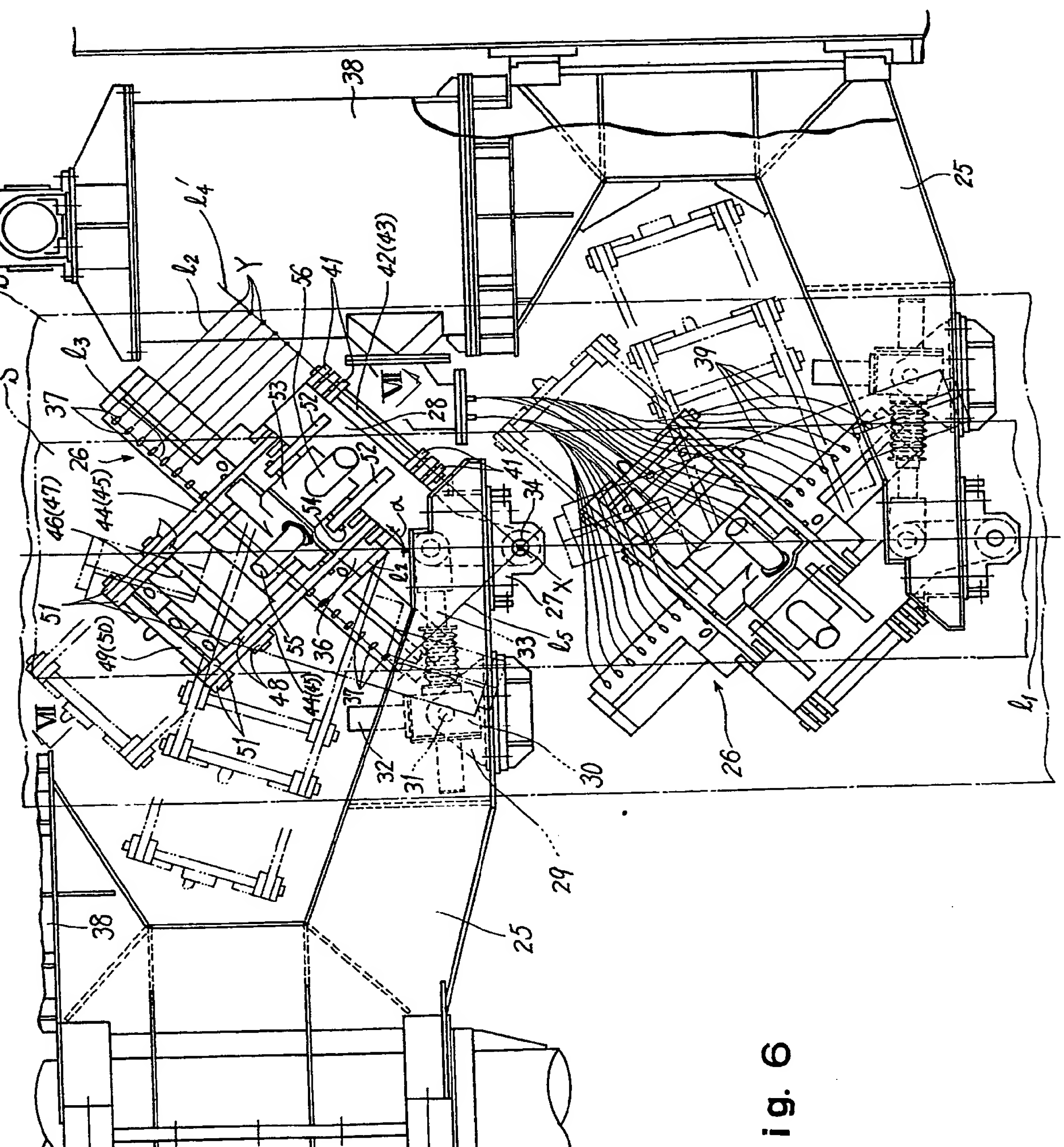
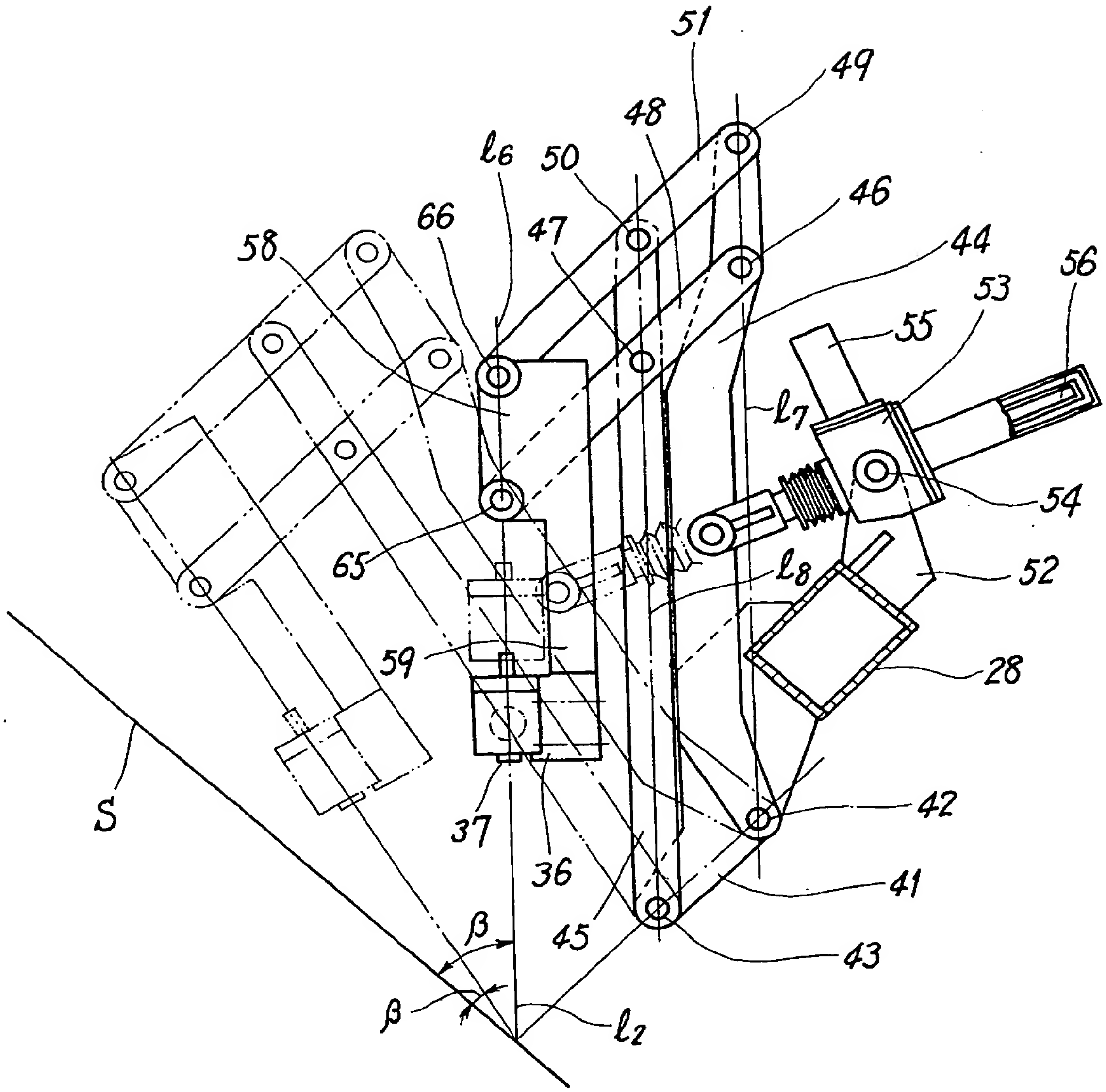


Fig. 6

Fig. 7



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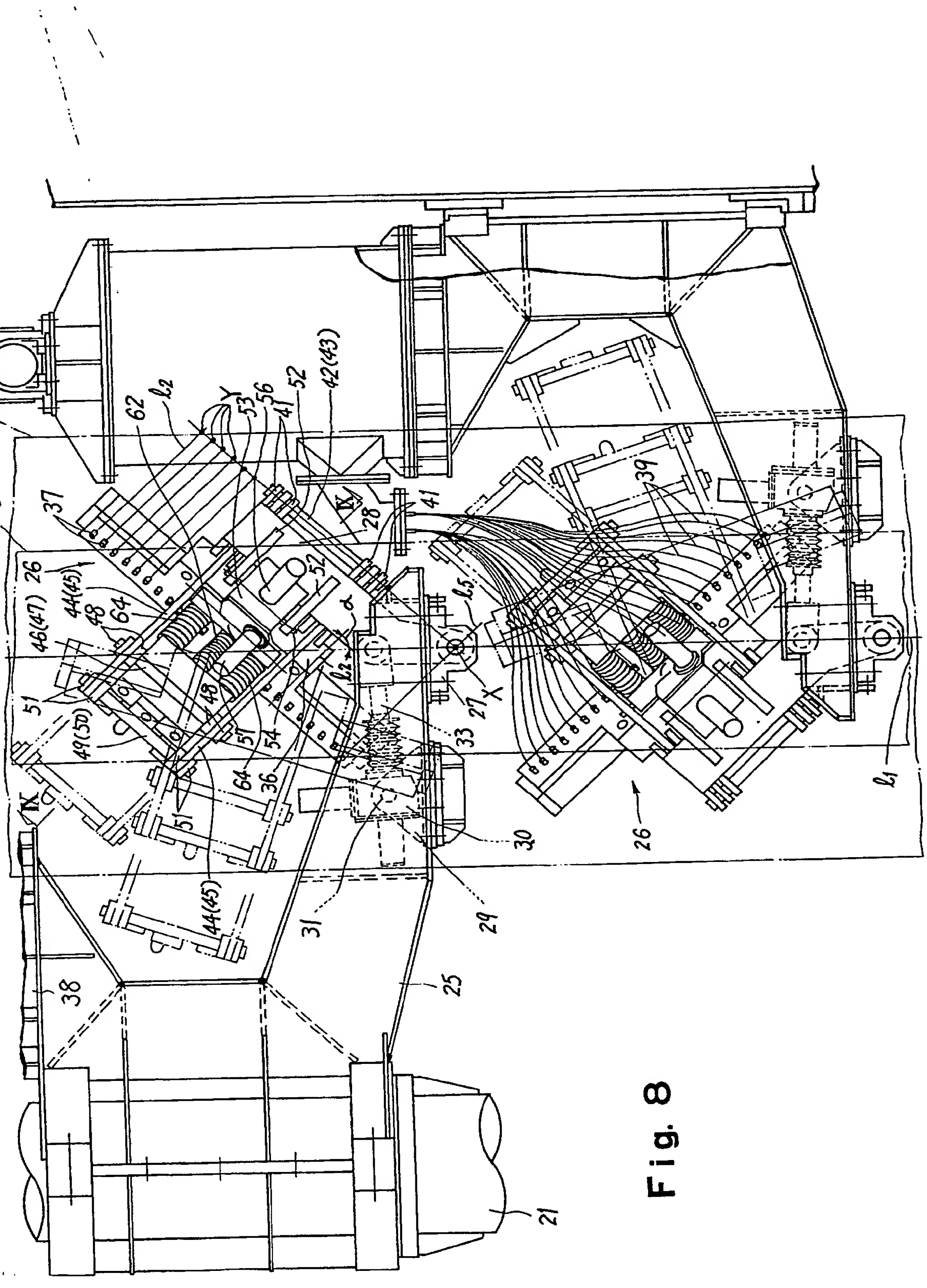
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Fig. 8

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Fig. 9

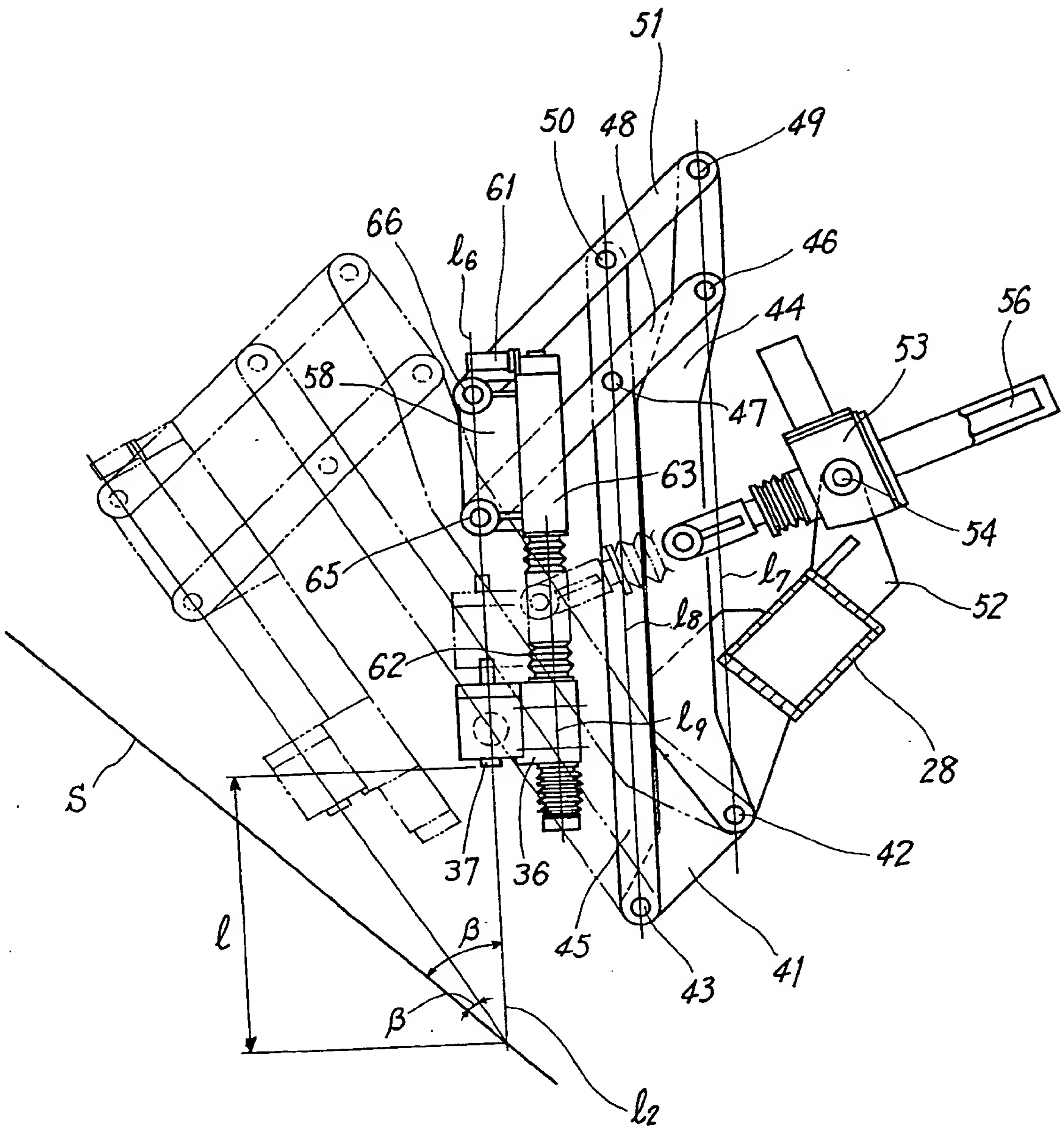


Fig. 10

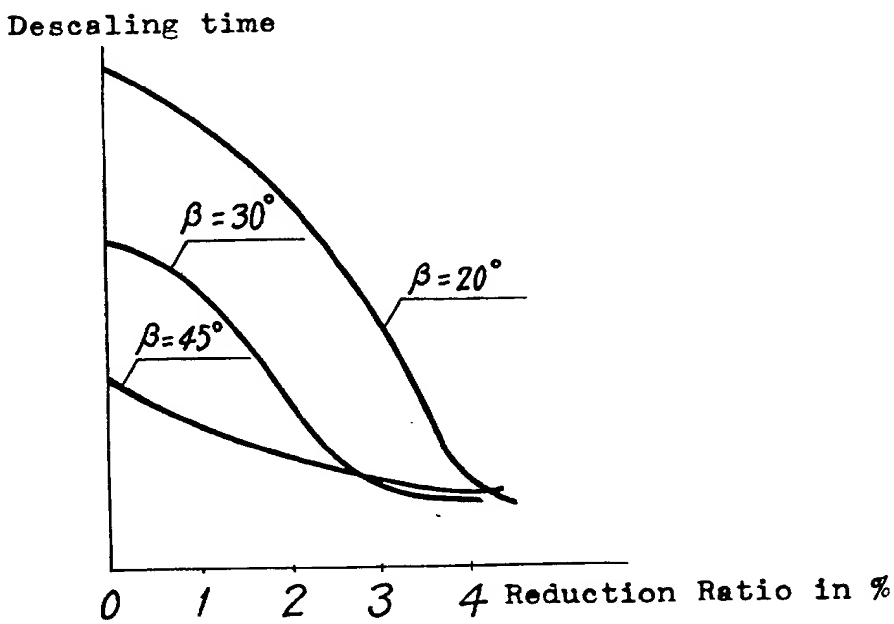
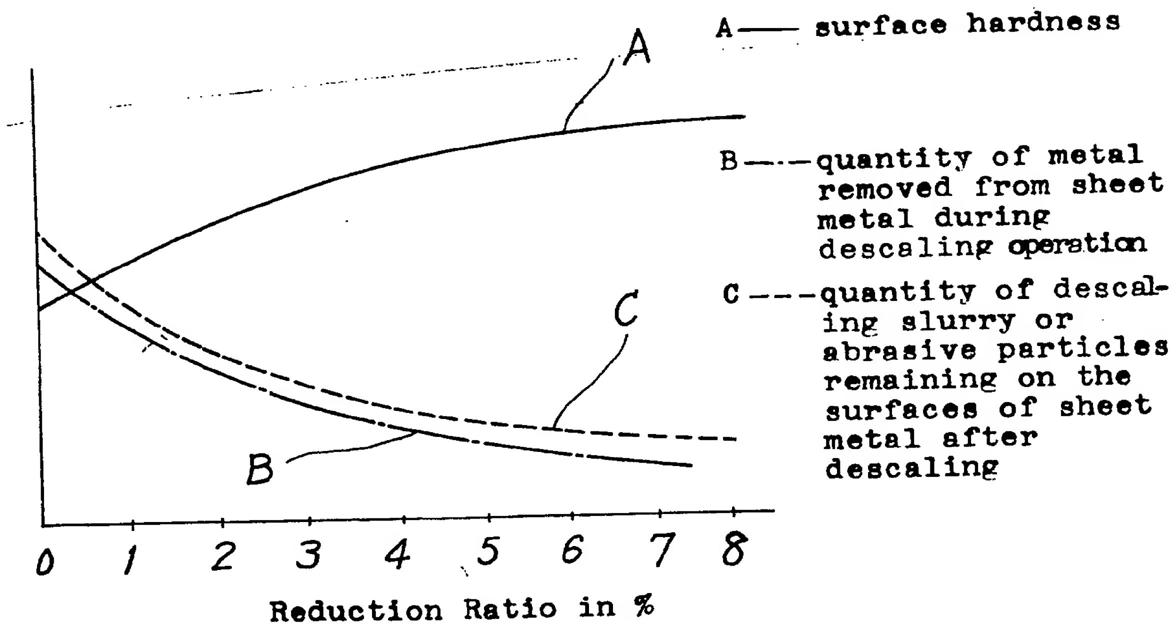

Descaling time
β=30°
β=20°
β=45°
0
1
2
3
4
Reduction Ratio in %

Fig. 11


A
C
B
0
1
2
3
4
5
6
7
8
Reduction Ratio in %
A —— surface hardness
B —·— quantity of metal removed from sheet metal during descaling operation
C - - - quantity of descaling slurry or abrasive particles remaining on the surfaces of sheet metal after descaling

SPECIFICATION

Mechanical descaling device

The present invention relates to a mechanical descaling device for continuously descaling hot rolled sheet metal before it is subjected to cold rolling.

In cold rolled sheet metal production lines a coil of hot rolled sheet metal is first uncoiled, and scales on the surfaces of the sheet metal must then be completely removed before the sheet is subjected to cold rolling which further reduces the sheet metal to a desired gauge.

In general, in conventional cold rolled sheet metal production lines, the uncoiled hot-rolled sheet metal is made to pass through an acid such as hydrochloric or sulphuric acid in order chemically to remove the scales on the surface of the sheet metal. Such a chemical descaling process takes a long time and is inefficient. Furthermore, it requires additional installations for recovering and neutralizing the acid after use. For this reason the overall length of a chemical descaling line (often referred to in the art as a "pickling line" which term will be used hereinafter in this specification) is excessively long. Moreover, the pollution problems due to the use of strong acids must be taken into consideration. Therefore, and because of high capital cost and high running costs, the production cost of cold rolled sheet metal using a pickling line is very high.

There is a further disadvantage of the use of a pickling line; this is that the pickling line cannot in general be operated continuously with the cold rolling line. As a result, after passing through the pickling line, the sheet metal must be recoiled and transported to a storage area, from where the coils of sheet metal must be transported again by cranes or trucks to the cold rolling line. Therefore, a large area must be provided between the pickling line and the cold rolling line for the temporary storage of the coils of sheet metal. Moreover, during such storage of the coils, the sheet metal may be subject to corrosion due to attack by any pickling acid remaining on the surfaces. To overcome this problem, it is necessary to provide, at the downstream end of the pickling line, a device which operates to apply an anti-rusting oil to the sheet metal as it emerges from the pickling line.

Various methods have been proposed in order to enable the pickling line to be connected directly to the cold rolling line in order to attain an increased productivity. All of the methods however have encountered the following problems.

First, the rate at which the pickling acid dissolves the scales on the she t metal is gen rally constant so that the sheet metal must be moved continuously, and at a constant velocity, through the pickling vessel which is of considerable length. On the other hand, the velocity f the sheet metal entering the first cold rolling stand in the cold rolling line must be varied in depend nce on various cold rolling conditions and requirements, such as the reduction ratio. Thus it is effectively impossible to connect the output of the pickling line dir ctly to the input nd of the cold rolling line.

Second, if the sheet metal is passed through the pickling line at a velocity lower than a predetermined velocity, over-descaling occurs and poor yields result. Furthermore, degradation in quality and variations in properties of the sheet metal result because of the strong attack by the pickling acid. Excessive consumption of pickling acid also results, with a resultant increase in pickling cost.

Since the cold rolling line must be shut down periodically to replace the rolls according to a pass schedule, an extremely large accumulator for temporarily accumulating a suitable length of sheet metal must be installed at both the upstream and downstream ends of the pickling line. Finally, the pickling acid remaining on the sheet metal may attack parts of the devices following the pickling line and, moreover, fumes from the pickling acid evolving from the pickling line may attack the equipment and devices, especially the motors which drive the rollers, if they are located in the vicinity of the pickling line.

As described above, the provision of a continuous cold rolled sheet metal production line incorporating a pickling line is very difficult. Therefore many efforts have been made to provide mechanical descaling devices which can be combined with a cold rolling line for the purpose of obtaining continuous production of cold rolled sheet metal from a coil of hot-rolled sheet metal. In one mechanical descaling device so far proposed, a descaling slurry made of abrasive particles is blasted through nozzles, together with water under high pressure, against the surfaces of the sheet metal to be treated. However, these nozzles are in general fixed so that not only can the angle between the axis of the nozzle and the centre-line of the sheet metal being descaled not be varied, but also the angle between the nozzle axis and the plane of the sheet metal cannot be varied either. Moreover, the distance between the nozzle tip and the surface of the sheet metal cannot be varied. As a result, the conditions under which descaling operations are performed cannot be varied to suit different dimensions, properties and desired surface conditions of the particular sheet metal being produced at any one time, thus resulting in a waste of energy and a poor surface finish. Furthermore, with fixed nozzles, inspection and maintenance are difficult, and whenever it is desired to change the angles of the nozzles and/or the distance between the nozzle tip and the sheet metal, the production line must be completely shut down, thus resulting in a decrease in productivity.

Accordingly, the present invention seeks to provide an improved mechanical descaling device which may substantially overcome the above and other problems encountered in the prior art devices. The present invention therefore provides a mechanical descaling device including means for guiding a sheet of metal to be descaled along a predetermined path therethrough, and a plurality of nozzle assemblies, each nozzle assembly including a support member carried on a shaft supported in such a way that the extension of the axis of the shaft intersects the centreline of the sheet of metal to be descaled at right angles to the plan thereof, th supporting

member being turnable about the shaft by driving means, and a plurality of nozzles spaced along the said supporting member in one row, the axes of the said nozzles being parallel to each other and the extension of each nozzle axis intersecting the facing surface of the sheet of metal to be descaled at a given angle, the straight line connecting the tips of the nozzles being parallel to the facing surface of the sheet of metal to be descaled, and being inclined at an angle to the said centreline thereof, the extension of the nozzle axis of one of the said nozzles, which is positioned so as to project in use a jet of descaling slurry onto the surface of the sheet of metal at the centreline thereof intersecting the extension of the axis of the said shaft at the said facing surface of the said sheet of metal.

Various preferred embodiments of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic diagram of a continuous cold rolled sheet metal production line provided with mechanical descaling devices in accordance with the present invention;

Figure 2 is a schematic diagram of another example of a continuous cold rolled sheet metal production line with mechanical descaling devices in accordance with the present invention;

Figure 3 is a front view of a first embodiment of a mechanical descaling device of the present invention;

Figure 4 is a fragmentary front view, on an enlarged scale, of the mechanical descaling device shown in Figure 3, illustrating its arrangement of nozzle assemblies;

Figure 5 is a view as seen in the direction indicated by the arrows V in Figure 4;

Figure 6 is a fragmentary front view of a second embodiment of a mechanical descaling device of the present invention;

Figure 7 is a view as seen in the direction indicated by the arrows VII in Figure 6;

Figure 8 is a fragmentary front view of a third embodiment of a mechanical descaling device of the present invention;

Figure 9 is a view as seen in the direction indicated by the arrows IX in Figure 8; and

Figures 10 and 11 are graphs useful in explaining the operation of the descaling device of the present invention.

In the following description the same reference numerals are used throughout to designate the same or similar parts in different Figures.

Referring now to Figures 1 and 2, there are shown, in sequence from the left, a coiling device such as a payoff reel 1 from which is drawn a she t S of metal such as steel, a flatt ner 2, an upcut shear 3, a flush butt welder 4, a bridle roll 5, and a side trimmer 6 such as a scrap bor r or a chopper. In conventional d scaling lines, the side trimmer 6 has been dispos d at the downstream end of th pickling line, wheereas in the embodiment of the present invention it is disposed at the upstream end of a mechanical descaling apparatus in order to attain energy saving. The control of tension exerted on the sheet metal is effected by a conventional electrical system.

Downstream of the side trimmer 6 are disposed two pairs of bridle rolls 7 and 8 which are longitudinally spaced from each other, and disposed between them is a scale breaker 9 which has the dual function of correctly reshaping the sheet metal S and of reducing the same under a high reduction pressure, with a reduction ratio of more than 6%, so as uniformly and highly efficiently to descale the sheet metal passing therethrough. The scale breaker 9 may be a skin pass mill or a leveller. In conventional descaling lines, with a skin pass mill, the reduction ratio is of the order of 1% at most, but it is to be emphasized that in accordance with the present invention the reduction ratio is higher than 6%.

Downstream of the scale breaker 9 are disposed a plurality of sets of mechanical descaling devices 10 which mechanically descale the surfaces of the sheet metal S so that it may be subjected to cold rolling. The mechanical descaling devices 10 may be one or more of various types such as liquid honing, shot blasting, buff rolling and so on. In the descaling line shown in Figure 1, liquid honing type descaling devices 10 are employed. As will be descrbed in detail hereinafter, each of the descaling devices 10 normally blasts a descaling slurry incorporating iron filings, sand or like abrasive particles against the surfaces of the sheet metal S through nozzles. Simultaneously, it also blasts water under high pressure (of the order of 25 to 200 kg/cm^2 G) through different nozzles so as to cause the descaling slurry to accelerate toward the surfaces of the sheet metal S. Thus the mechanical descaling devices 10 operate highly efficiently to descale the sheet metal S.

At the downstream end of the mechanical descaling station comprising the descaling devices 10 is disposed an after-treatment device 11 for blasting fresh clean water under high pressure against the surfaces of the sheet metal S, thereby removing any descaling slurry attached thereto.

Downstream of the after-treatment device 11 is disposed a continuous cold rolling line 12 comprising a plurality of roll stands arranged in tandem. The cold rolled sheet metal leaving the cold rolling line 12 passes a pair of bridle rolls 13 and an upcut shear 14 and is rolled around a coiling device 15 which exerts suitable tension to the sheet metal S and aligns the edges thereof as it is rolled.

In the embodiment illustrated in Figure 2, in addition to the above explained devices the descaling line further includes an accumulator 16 between the bridle rolls 8 and the mechanical descaling station 10. The reason the accumulator 16 is disposed downstreamm of the welder 4 is so that the former will not interfere with the operation of the welder 4 for joining the trailing edge of a preceding sheet of metal and the l ading edge of a following sheet of metal, or the perations f llowing th weld r 4.

Next, referring to Figures 3, 4 and 5, the mechanical descaling device 10 will be described in detail. Suitable sheet metal transport means is provided so that the sheet metal S may pass vertically through a casing 17 from top to bottom or vice versa. Rails 20

are securely attached with brackets (not shown) to columns 18 and xtend parallel to the surface of the sheet metal S. Within the space defined by four columns 18 is disposed a movable frame constituted by four cylindrical columns 21 disposed at the corners of the frame and connected to each other with transverse beams 22 and 23. The transverse beams 23, which extend parallel to the surface of the sheet metal S, are provided with wheels 24 riding on the rails 20. Hydraulic cylinders (not shown) extending parallel to the rails 20 are operatively coupled to the beams 22 in such a way that as the hydraulic cylinders are extended or retracted the movable frame may travel transversely along the rails 20 parallel to the surface of the sheet metal S.

Rotary arms 25 are mounted on the columns 21 in such a way that they are rotatable about the axes of the columns 21, each rotary arm 25 carrying a nozzle assembly 26. Of the four nozzle assemblies 26 shown in Figure 3, two serve for descaling one surface of the sheet metal S while the other two serve for descaling the other surface thereof. As best shown in Figure 4, the uppermost nozzle assembly 26 is s arranged as to descale the right half (from the centrline ℓ_1) of one surface of the sheet metal S while the second highest nozzle assembly 26 is arranged for descaling the left half of this surface. In like manner, the third highest nozzle assembly 26 is arranged so as to descale the right half of the other surface of the sheet metal S whereas the fourth or lowermost nozzle assembly descales the left half of this other surface. It is of course possible to extend the width of a nozzle assembly 26 to such an extent that one nozzle assembly may descale the whole of one surface of the sheet metal. Furthermore, any number of descaling nozzle assemblies 26 may be provided, and these may be disposed in any suitable array as needs demand.

As best shown in Figure 4, each nozzle assembly includes a box-shape supporting member 28 carried on a shaft 34 journalled in bearings 27 securely attached to the lower surface of the rotary arm 25 adjacent to the free end thereof in such a way that the axis X of the shaft 34 may perpendicularly intersect with the centreline ℓ_1 of the sheet metal S. A worm gearing or reduction gear 30 has its casing pivoted by pivot pins 31 to a bracket 29 which in turn is mounted on the rotary arm 25 about halfway along its length. The worm wheel of the reduction gear 30 is operatively coupled to a motor 32 while the associated shaft 33 has one end pivotably connected to the box-shape supporting member 28 at a point above the shaft 34. Therefore, as the motor 32 is driven to rotate the worm wheel in either direction the worm shaft 33 is ext nded toward the right (as vi wed in Figure 4) or toward the left so that the box-shape supporting member 28 is caused to swing about th shaft 34 in the clockwise or counterclockwise direction away from or towards the column 21 on which it is ultimately supported. The nozzle assembly 26 extends upwardly obliquely at an angle relative to the vertical.

Still referring to Figure 4, a nozzle mounting block 36 is carried, by a pair of transversely spac d brackets 35, on the box-shape supporting member 28 so as to extend parallel thereto. A plurality of nozzle bodies 37 are mounted on the block 36 and spaced apart by a suitable distance from each other in the transverse direction. These nozzle bodies 37 are in hydraulic communication, through respective flexible hoses 39, with an associated mixing chamber 38 mounted on the top of each rotary arm 25 (see Figure 3). The nozzle bodies 37 are so arranged that their nozzle axes ℓ_2 intersect at Y the straight line ℓ_4 which is the projection one or the other surface of the sheet metal S of a line which extends parallel to the straight line ℓ_3 connecting the tips of the nozzle bodies 37 and intersects the axis X of the shaft 34 at right angles thereto (See also Figure 5). Furthermore the extension of the nozzle axis ℓ_5 of the nozzle body 37 nearest the pivot axis of the assembly coincides, i.e. passes through, the point (indicated by X in Figure 4) at which the projected straight line ℓ_4 intersects the centreline ℓ_1 of the sheet metal S, this point also lying on the axis of the pivot pin 34.

In Figure 4 the angle between the nozzle axis ℓ_2 of each nozzle body 37 and the centreline ℓ_1 of the sheet metal S is indicated α. This angle α may be varied to suit the descaling conditions such as the width of the sheet metal S, by operation of the motor 32. Therefore, the positions of the points Y at which the descaling slurry jets emitted by the nozzles 37 impinge against one or other surface of the sheet metal S can be varied.

Referring now to Figure 5, the angle between the nozzle axis ℓ_2 of each nozzle body 37 and the plane of the sheet metal S is indicated β. This angle β, which will be referred to as "the incident angle" is fixed at an optimum angle and cannot be varied. The travelling distance ℓ between the nozzle tip and the surface of the sheet metal is also fixed at an optimum distance and cannot be varied.

Means (not shown) are provided to supply water under high pressure to the nozzle bodies 37 so that the descaling slurry may be blasted towards the sheet metal S at a high speed. Furthermore, a suitable descaling slurry receiving means such as a tank is disposed below the casing or stationary frame 17 so as to collect the used descaling slurries.

Referring back to Figure 3, the descaling slurry is charged into the mixing chamber 38 through a cyclone 40 which has the function of condensing the descaling slurry.

The operation of the descaling line with the descaling devices 10 described with reference to Figures 1 to 5 is as follows- The coil of sheet metal S is uncoiled by the uncoiling device 1, and flattened by the flattener 2. The portion at the leading edge of the sheet metal S which is not of the correct gauge is cut off by the upcut shear 3 in such a way that the cut-off leading edge is perpendicular to the axis or centreline ℓ_1 of the sheet metal S. The flush-butt welder 4 welds the leading edge thus prepared by the upcut shear 3 to the trailing edge of the preceding sheet metal S which has been similarly edge prepared. Thereafter the side trimmer 6 cuts off th sides of the sheet metal S. The scale breaker 9 mechanically breaks up th scales on the sh et m tal S so that the optimum descaling effect may be attained by the mechanical descaling devices 10. In

addition, the scale breaker 9 has a function of flattening the sheet metal S by reduction under high pressure or by bending. Otherwise, if sheet metal S with a waving or undulating surface passes the deflector rolls in the mechanical descaling devices 10 under tension, these surfaces do not follow a straight path so that the desired descaling effects cannot be attained.

The sheet metal S emerging from the scale breaker 9 may be temporarily accumulated in the accumulator 6 as shown in Figure 2 before it is fed into the mechanical descaling device 10. In the mechanical descaling device 10, the angular position of each nozzle assembly 26 is adjusted in dependence on the width of the sheet metal S. To this end, the motor 32 is energized so as to extend or retract the worm shaft 33 in the manner described in detail above, whereby the nozzle assembly 26 may be brought to an optimum angular position as indicated by the solid lines in Figure 4.

The descaling slurries are charged through the flexible hoses 39 from the mixing chamber 38 to the nozzle main bodies 37 and mixed with water under high pressure which is supplied separately as described above. Thus, the descaling slurry jets are blasted at high pressure against the surfaces of the sheet metal S so that scales can be completely removed.

If the sheet metal S oscillates laterally when passing through the mechanical descaling device 10, the nozzle axis ℓ_5 of the lower-most nozzle body 37 will fail to intersect the centreline ℓ_1 of the sheet metal S. As a result, the nozzle assemblies 26 cannot attain the descaling of all of the right and left halves of one or the other surface of the sheet metal S. To overcome this problem, according to the present invention, means for sensing lateral oscillations of the sheet metal S are provided so that in response to this sensing the movable frame (constituted by the columns 21 and the beams 22 and 23) can be moved along the rails 20 parallel to the sheet metal S so that the axis X of each nozzle assemblies 26 continually intersects the centreline ℓ_1 of the sheet metal S (See Figure 4) and consequently at least one pair of nozzle assemblies 26 will be properly positioned to descale the right and left halves of one or the other surface of the sheet metal S.

If the sheet metal S has a relatively small width, the motors 32 are energized to drive the worm shaft 33 in such a direction that the supporting members 28 are swung about the axis X to increase the angle α. Thus the nozzle assemblies 26 are brought to the angular position indicated by chain lines in Figure 4 and effectively cover the right or left half of one or the other surface of the sheet metal S with a relatively small width. Even though the angular position of the nozzle assembly 26 has been changed, the intersection between the nozzle axis ℓ_5 of the lowermost nozzle body 37 and the centr line ℓ_1 of th sheet metal S remains unchanged at position X of Figur 4. Thus, even when the angular positions of th nozzle assemblies 26 are changed, there will not be any area left on one or the other surface of the sheet metal S upon which the descaling slurry jets from one or the other nozzle assemblies 26 does not impinge. Furthermore there will be no area of the sheet upon which descaling slurry jets from more than one nozzle assembly 26 impinges. Thus the whole surfaces of the sheet metal S will be descaled uniformly and completely.

During the descaling operation, the rotary arms 25 are maintained in their operative position with stop pins or the like (not shown). In order to inspect the nozzle assembly 26, the stop pin or the like is removed to permit the rotary arm 26 to rotate about the column 21 so that the nozzle assembly 26 may project outwardly of the stationary frame 17. Since the mixing chamber 38 is mounted above the rotary arm 25, it is not needed to remove the flexible hoses 39 from the nozzle assembly 26 when the latter is moved out of its operative position in the manner described above.

After the sheet metal S has been completely descaled by the mechanical descaling devices 10, it is thoroughly cleaned with fresh water under high pessure in the after-treatment device 11 and then cold rolled in the cold rolling line 12 (See Figures 1 and 2). The cold rolled sheet metal S has an anti-rusting oil applied to it when it passes the deflector roll 15, and is recoiled again by the recoiling device 16. When the sheet metal S has been wound into a roll to a predetermined diameter, the upcut shear 14 is operated to cut off the sheet metal S.

Next, referring particularly to Figure 10, there is explained the reason why the sheet metal S is subjected to the reduction under high pressure in the scale breaker 9 before it is fed into the mechanical descaling device 10. It has been found that if the reduction ratio is between 6% and 8%, complete descaling may be effected within a short time with any incident angle β from 20° to 45°. For instance, with an incident angle β of 45°, the descaling time is reduced by almost one half of that taken by prior art systems, when the sheet metal has been reduced by between 6% and 8%. In other words, the descaling efficiency may be doubled.

Furthermore, as indicated by the solid line A in Figure 11, the higher the reduction ratio, the higher the surface hardness of the sheet metal S becomes. As a consequence, the quantity of the metal removed from the sheet metal S during the descaling operation may be reduced as indicated by the chain line curve B in Figure 11. That is, a high yield may be ensured. In addition, as the surface hardness increases, the penetration of the abrasive particles into the surfaces of the sheet metal S is reduced as indicated by the dashed line curve C in Figure 11 so that the ratio of the quantity of abrasive particles remaining on the surfaces of the sheet metal S to the total quantity of abrasive particles incident against them may be considerably reduced.

As descrbed hereinbefore, the descaling of the pr sent invention may be continuously carried out from the uncoiling of the hot rolled sheet metal, through cold rolling of the sheet, to r coiling of the cold rolled sheet metal. As a result, necessity for recoiling and uncoiling devices immediately before the cold rolling line 12 may be eliminated. Furthermore the need for an accumulator such as loop

cars may be eliminated. Moreover, since the mechanical descaling devices 10 of the present invention are highly effective, and efficiently descale the sheet metal, pickling apparatus and its associated equipment may be eliminated. Consequently, coil storage between the pickling line and the cold rolling line may be eliminated, and means for transporting the coils from the pickling line to the cold rolling line are no longer required. Thus, the whole cold rolled metal sheet production line starting from the uncoiling device and ending at the recoiling device through the steps of sizing, descaling, surface cleaning and cold rolling may be made very compact in size.

In addition, a saving in energy and materials is obtained in that the drying device following the pickling line can be eliminated. And since, after having been descaled, the sheet metal S is applied with a lubricating oil and is immediately subjected to cold rolling, the oiling device for applying an anti-rusting oil to the sheet metal as it emerges from the pickling apparatus may be eliminated.

Referring back to Figures 1 and 2, the side trimmer 6 is disposed upstream of the mechanical descaling devices 10. This means that the sheet metal S to be descaled is narrower in width than the sheet metal as uncoiled; clearly the energy required for descaling sheet metal the sides of which have been cut off is less than would be the case if the sheet metal as uncoiled were fed into the descaling device.

Prior to descaling by the mechanical descaling devices 10, the sheet metal S is made to pass through the scale breaker 9 so that it may be corrected in shape and reduced at a high reduction ratio as described above. As a result, the density or distribution of scales on the surfaces of the sheet metal may become uniform so that uniform and highly efficient descaling by the mechanical descaling devices 10 can be effected.

Since the scale breaker 9 trues the shape of the sheet metal, descaling may be performed at high speeds. The angular positions of the nozzle assemblies 26 may be varied in dependence on the width of the sheet metal to be descaled in the manner described above, and the properties of the descaling slurry and the pressure of the descaling slurry jets may be varied to optimise them in dependence on the properties of the sheet metal to be descaled. Moreover, maintenance and inspection of the nozzle assemblies 26 can be effected by taking these off-line one at a time without stopping the cold rolled metal production line if required, so that a high productivity may be ensured.

Figures 6 and 7 illustrate a second embodiment of the invention. While the first embodiment described above with reference to Figures 3 to 5 may be adjusted to vary the angle α, the second embodiment to be described in detail below with reference to Figures 6 and 7 may be adjusted to vary not only the angle α but also the descaling slurry incident angle β, even during the descaling operation.

As in the case of the first embodiment, a box-shaped supporting member 28 is carried for swinging movement by a shaft 34 which in turn is j urnalled by bearings 27 attached to a rotary arm 25. A thre -dimensional parallel linkage or pantograph is mounted on th supporting member 28. This comprises a pair of two-dimensional parallel linkages each comprising, as shown in Figure 7, two parallel links 44 and 45 and two parallel connecting rods 48 and 51. The lower ends of the links 44 and 45 are pivoted respectively to shafts 42 and 43 which in turn are journalled on spaced brackets 41 and extend parallel to the longitudinal axis of the supporting member 28. One end of each of the connecting rods 48 and 51 is pivoted to a respective shaft 46 and 49, which extend parallel to the shafts 42 and 43. Two points of the connecting rods 48 and 51, which are spaced from the axes of the shafts 46 and 49 by the same distance as that between the axes of the shafts 42 and 43, are pivoted to two shafts 47 and 50 respectively, which also extend parallel to the shafts 42 and 43 and hence to the shafts 46 and 49. The other ends of the connecting rods 48 and 51 are pivoted to shafts 65 and 66 respectively, which latter, in turn, are pivotally connected to spaced brackets 58 each having an extension 59 connected rigidly to the nozzle mounting block 36. Therefore the said other ends of the connecting rods 48 and 51 are directed toward the sheet metal S as can be seen in Figure 7.

A worm gear 53 is pivoted by pivot pins 54 to mounting brackets 52 which in turn are securely attached to and extend from the side wall of the box-shape supporting member 28 opposite to that on which are attached the brackets 41. The worm wheel of the reduction gear 53 is cperatively connected to a motor 55, and one end of the worm shaft 56 is pivoted to the link 44 about halfway between its ends. Therefore, when the motor 55 is energized to drive the worm wheel in either direction, the worm shaft 56 is caused to extend (towards the left as viewed in Figure 7) or to retract (toward the right as viewed in Figure 7) so that the pantograph linkage is swung about the axes of the shaft 42 and 43 and consequently the angle of incidence β between the nozzle axis of each nozzle body 37 and the sheet metal S may be varied.

It is to be noted that the nozzle axis ℓ_2 of each nozzle body 37 is parallel to the line ℓ_6 joining the axes of the shafts 65 and 66, and to the line ℓ_7 joining the axes of the shafts 42, 46 and 49, as well as to the line ℓ_8 joining the axes of the shafts 43, 47 and 50.

As with the first embodiment, the nozzle bodies 37 are so arranged that the line ℓ_3 connecting the tips thereof is parallel to the axes of the shafts 42 and 43. The nozzle axes ℓ_2 of the nozzle bodies 37 intersect at Y the line ℓ'_4 defining the intersection between th sheet metal S and the plane containing the axes of the shafts 42 and 43 as can be seen in Figure 6. Furthermore, the extension of the nozzle axis ℓ_5 of the lowermost nozzle body 37 passes the point of intersection X between the line ℓ'_4 and the extension of the shaft 34 on the centreline ℓ_1 of the sheet metal S.

The angle α between the centreline ℓ_1 of the sheet metal S and the nozzle axes ℓ_2 of the nozzle bodies 37 may be varied in the manner described in r lation to the first embodiment. To vary the descaling slurry jet incid nt angle β, the motor 55 is energized so that the worm shaft 56 is moved to the left or right as

viewed in Figure 7. As a result, in the first case, the pantograph is caused to swing about the axes of the shafts 42 and 43 in the anticlockwise direction so that the incident angle β is reduced, as indicated by the broken lines in Figure 7; in the second case the pantograph swings in the clockwise direction so that the incident angle β is increased. However it is to be emphasized that the points Y at which the slurry jets are incident on the facing surface of the sheet metal S remain unchanged as can be seen from Figure 7. Thus, according to the second embodiment of the present invention, both the angles α and β may be adjusted to obtain optimum settings depending upon the descaling conditions.

The third embodiment shown in Figures 8 and 9 is substantially similar in construction to the second embodiment described hereinbefore with reference to Figures 6 and 7 except that there are further provided means to vary the distance ℓ between the tips of the nozzle bodies 37 and the facing surface of the sheet metal S.

Referring particularly to Figure 9, a hollow cylinder 63 is securely attached to the bracket 58 in such a way that the axis ℓ_9 of the cylinder 63 is parallel to the line ℓ_7 passing perpendicularly through the axes 42, 46 and 49, to the line ℓ_8 passing perpendicularly through the axes 43, 47 and 50 and to the line ℓ_6 passing perpendicularly through the axes 65 and 66. A lead screw 62 is rotatably mounted within the cylinder 63 and has its upper end operatively connected to a motor 61 so that the lead screw 62 may be rotated in either direction. The lead screw 62 is threaded into the nozzle mounting block 36.

The mounting block 36 is slidably mounted on guide rods 64 (See Figure 8) which extend parallel to the lead screws 62 and are spaced apart by a suitable distance outwardly therefrom. Protective bellows (See Figure 8) are fitted over the guide rods 64 between the nozzle mounting block 36 and the brackets 58 so that the guide rods 64 are protected from attack by the descaling slurries.

To vary the distance ℓ between the tips of the nozzle bodies 37 mounted on the mounting block 36 and the sheet metal S, the motor 61 is energized to rotate the lead screw 62 in one direction or the other. As a result, the nozzle mounting block 36 is moved upwards or downwards so that the distance ℓ may be increased or decreased as required by different descaling conditions. That is, the distance ℓ may be selected to be the optimum in dependence on the properties of the sheet metal S to be descaled.

A conventional production line consisting of a pickling line and a cold rolling line typically extends to about 350 metres, whereas the length of a cold rolled metal production line incorporating the mechanical descaling devic s of the present invention with a conventional cold rolling line is only one half of this length. Therefore it will b apparent that consid rable saving in capital cost may be attained.

The sheet metal emerging from the mechanical descaling device may be made continuously and smoothly to enter into the cold rolling line. As a result, the production time may be remarkably reduced, and at the same time the required number of operators may be drastically reduced to 1/3 of that required for conventional lines. For instance, prior art production lines typically take several days to cold roll the hot rolled sheet metal, whereas a production line incorporating the mechanical descaling devices of the present invention can reduce the production time to as short as a few hours.

CLAIMS

1. A mechanical descaling device including means for guiding a sheet of metal to be descaled along a predetermined path therethrough, and a plurality of nozzle assemblies, each nozzle assembly including a supporting member carried on a shaft supported in such a way that in use the extension of the axis of the shaft intersects the centreline of the sheet of metal to be descaled at right angles to the plane thereof, the supporting member being turnable about the shaft by driving means, and a plurality of nozzles spaced along the said supporting member in one row, the axis of the said nozzles being parallel to each other and the extension of each nozzle axis intersecting the facing surface of the sheet of metal to be descaled at a given angle, the straight line connecting the tips of the nozzles being parallel to the facing surface of the sheet of metal to be descaled, and being inclined at an angle to the said centreline thereof, the extension of the nozzle axis of one of the said nozzles, which is positioned so as to project in use a jet of descaling slurry onto the surface of the sheet of metal at the centreline thereof intersecting the extension of the axis of the said shaft at the said facing surface of the said sheet of metal.

2. A mechanical descaling device as claimed in Claim 1, in which the said plurality of nozzles are mounted on the said supporting means by a parallel linkage in such a way that the incident angle between the extension of the axis of each nozzle and the said facing surface of the sheet of metal to be descaled may be varied while the point of incidence at which the descaling slurry jet projected through each of the said nozzles impinges against the said facing surface of the said sheet of metal remains unchanged.

3. A mechanical descaling device as claimed in Claim 2, in which a lead screw is mounted on the said parallel linkage, with its axis parallel to the axes of the said nozzles, in such a way that it is rotatable about its own axis but is fixed axially with respect to its mounting, the lead screw being threadedly engaged into a member with respect to which the nozzles are fixed whereby to cause displacement of the nozzles, constrained by the said parallel linkage, upon turning about its axis.

4. A mechanical descaling device as claimed in any of Claims 1 to 3, in which disposed upstream of a first of the said plurality of nozzle assemblies there are located means for uncoiling a coil of hot rolled sheet metal, means for welding the trailing edge of a preceding uncoiled sheet of metal to the leading edge of a succeeding uncoiled sheet of metal, and means for cutting the sides of the sheet of metal to obtain substantially uniform sheet width throughout its length.

5. A mechanical descaling device as claimed in Claim 4, in which upstream of the said means for welding the trailing edge of a preceding uncoiled sheet of metal to the leading edge of a succeeding uncoiled sheet of metal there are further provided means for trimming the leading and trailing edges of successive uncoiled sheets of metal to shape so that the trailing edge of a preceding sheet can be located correctly in register with the leading edge of a succeeding sheet prior to entry into the said welding means.

6. A mechanical descaling device as claimed in Claim 4 or Claim 5, in which downstream of the said welding means there are provided means for temporarily accumulating a length of sheet metal emerging from the welding means.

7. A mechanical descaling device as claimed in any of Claims 4, 5 or 6, in which downstream of the said means for cutting the sides of the sheet of metal there are provided scale breaking means for rolling down under high pressure the sheet of metal emerging from the said means for cutting the sides of the sheet.

8. A mechanical descaling device as claimed in Claim 7, in which downstream of the scale breaking means there is provided an accumulator for temporarily accumulating a length of the sheet of metal emerging from the scale breaking means.

9. A mechanical descaling device as claimed in Claim 7 or Claim 8, in which the scale breaking means is operative to roll down metal passing therethrough at a reduction ratio of between 6% and 8%.

10. A mechanical descaling device as claimed in any preceding Claim, in which disposed downstream of the last of the said plurality of nozzle assemblies there are provided means for cleaning both surfaces of the sheet of metal after passing the said last of the nozzle assemblies.

11. A mechanical descaling device as claimed in Claim 10, in which disposed further downstream from the said cleaning means there are provided means for cutting a continuous length of sheet metal into shorter lengths.

12. A mechanical descaling device as claimed in Claim 11, in which disposed downstream from the said means for cutting a continuous length of sheet metal into shorter lengths there are provided means for recoiling the said shorter lengths of sheet metal.

13. A mechanical descaling device substantially as hereinbefore described with reference to Figure 1 or Figure 2 or Figures 3, 4 and 5, or Figures 6 and 7, or Figures 8 and 9 of the accompanying drawings.

14. A continuous cold rolled sheet metal production line provided with a mechanical descaling device as claimed in any preceding claim.

15. A continuous cold rolled sheet metal production line provid d with a mechanical descaling device as claimed in Claim 11 or Claim 12, in which the said cold rolling line is located downstream of the said cleaning means and upstream of the said means for cutting continuous length of sheet metal into shorter lengths.

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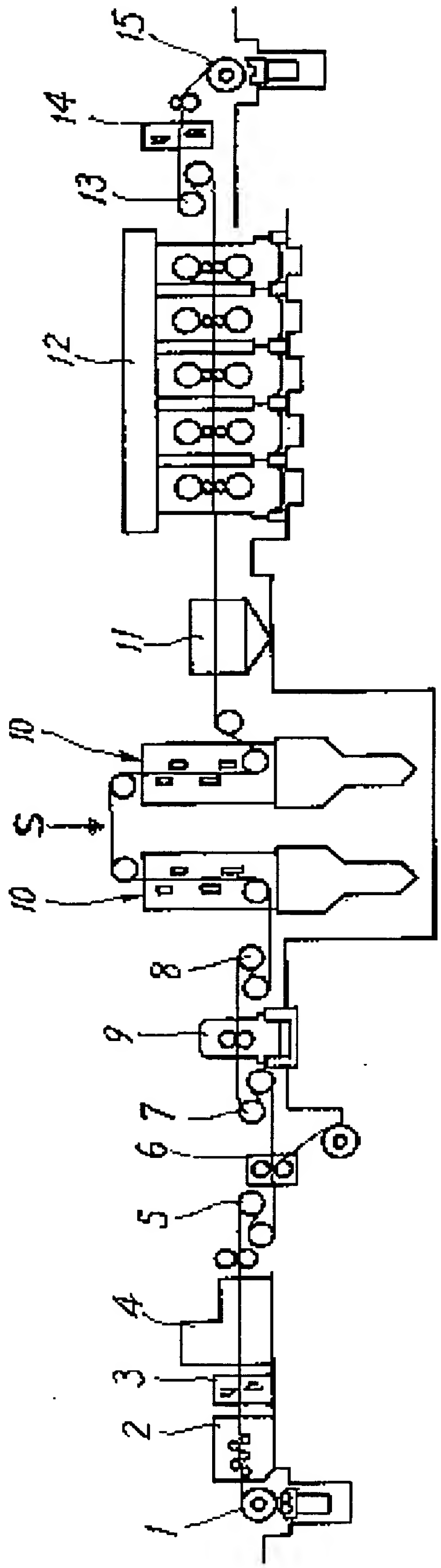


Fig. 1

Fig. 2

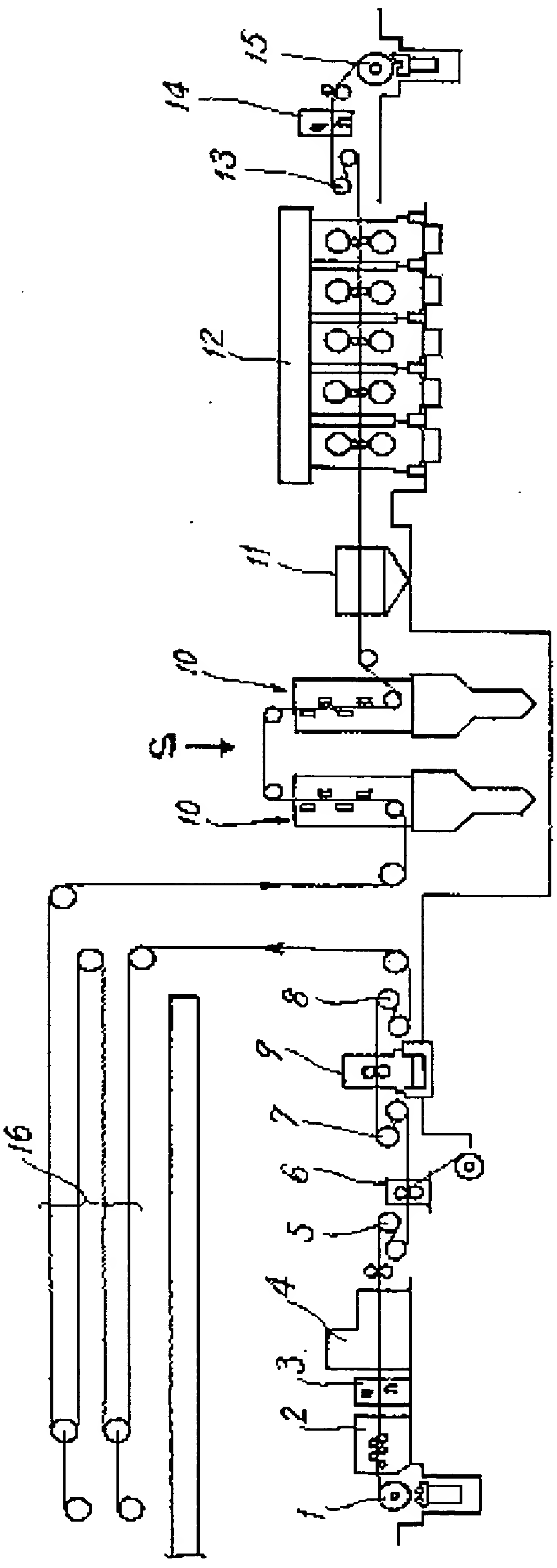
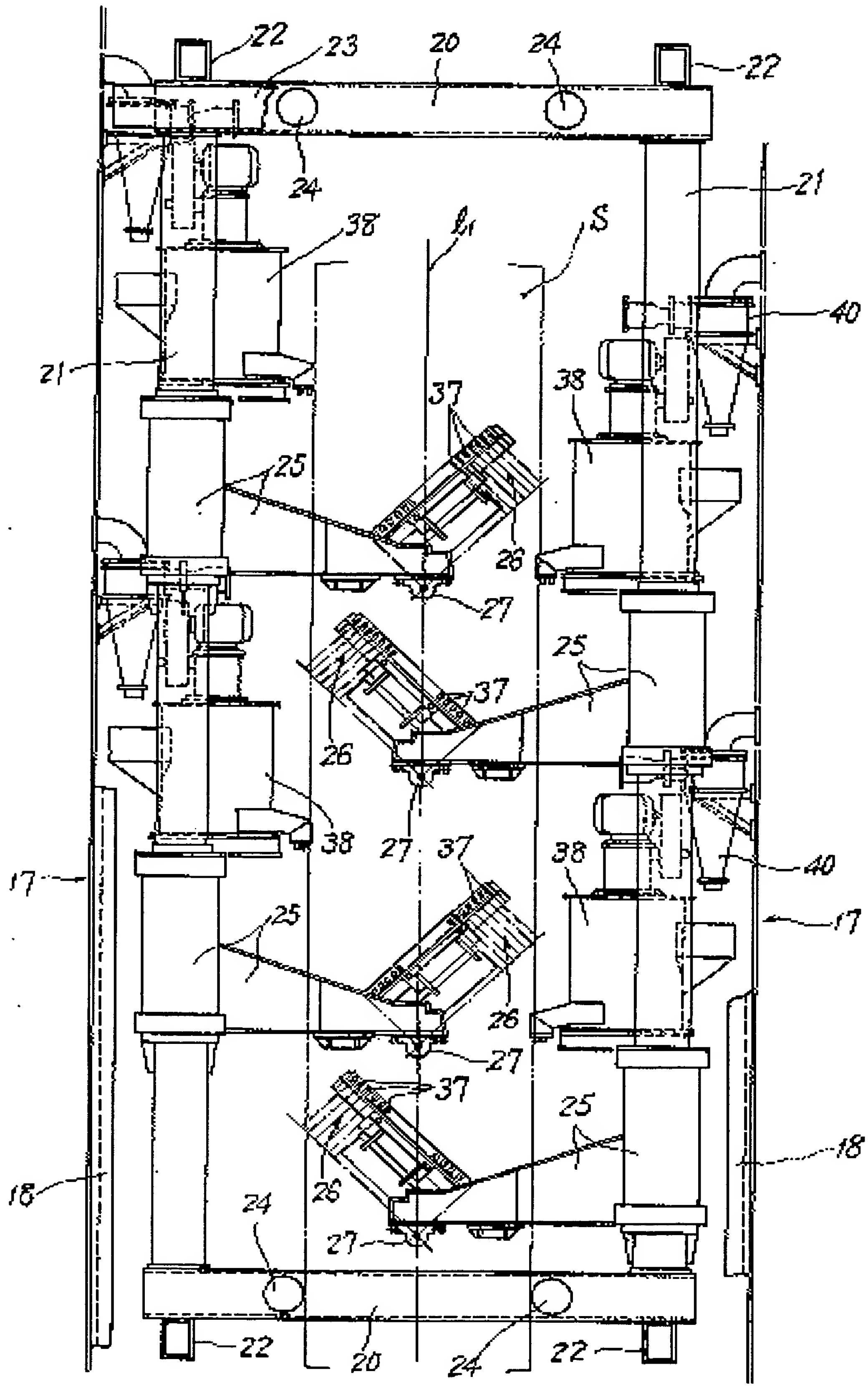


Fig. 3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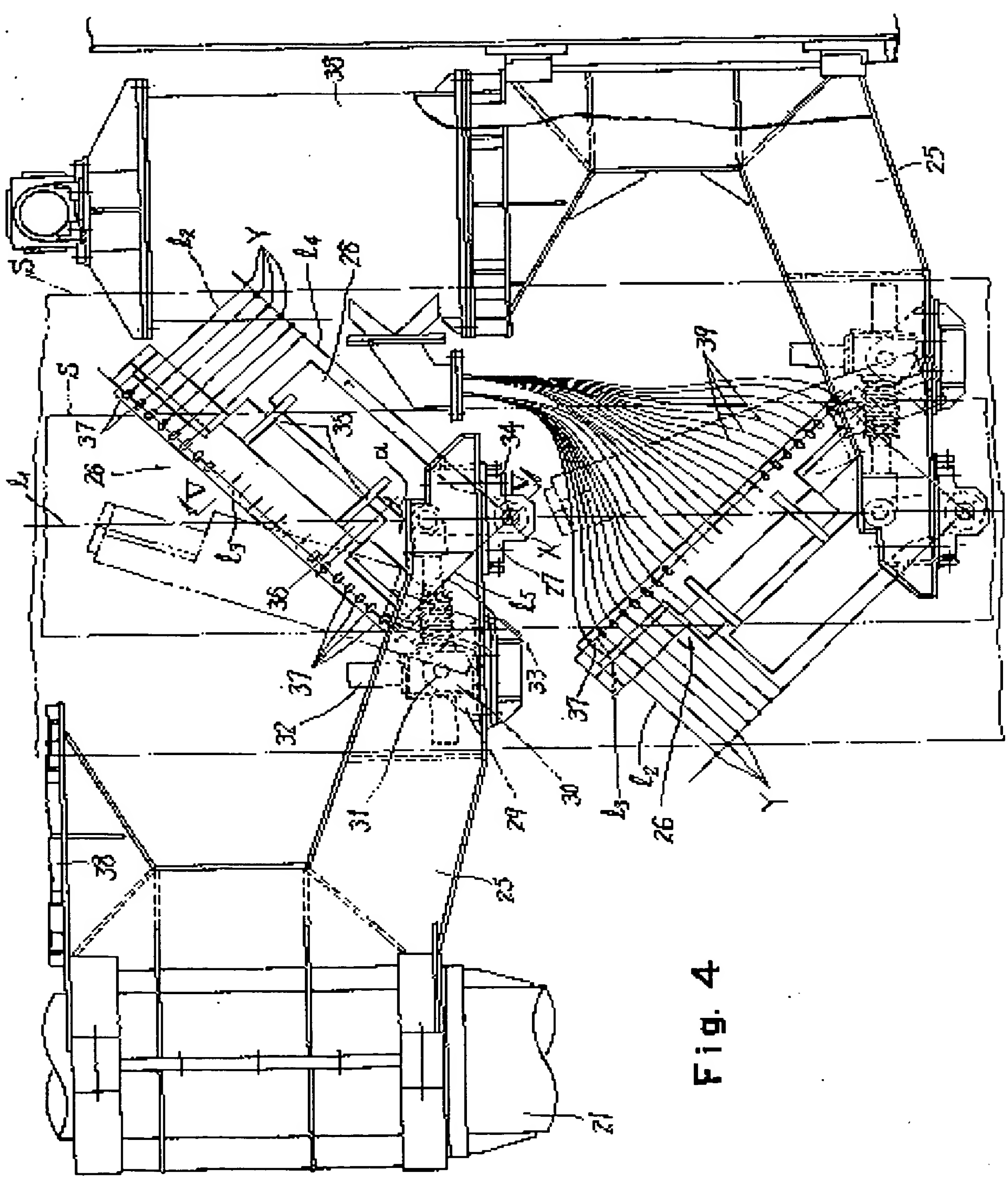
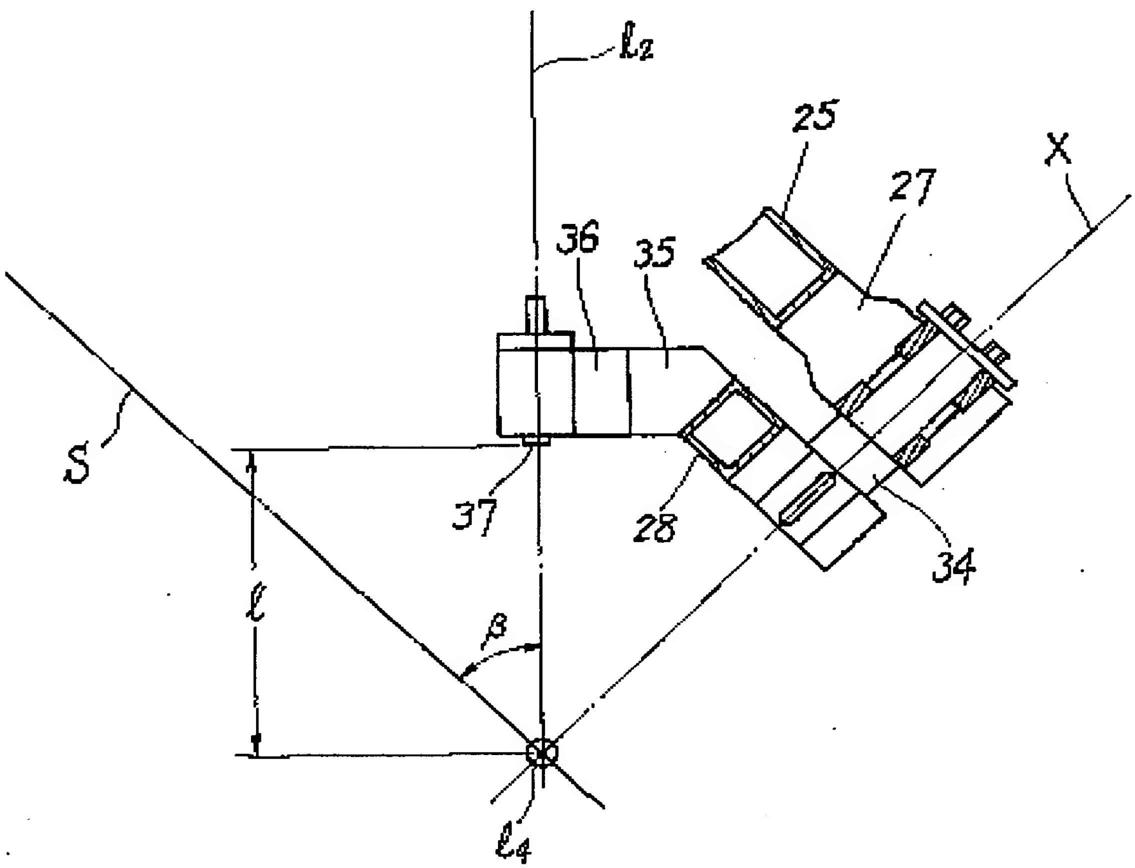


Fig. 4

Fig. 5



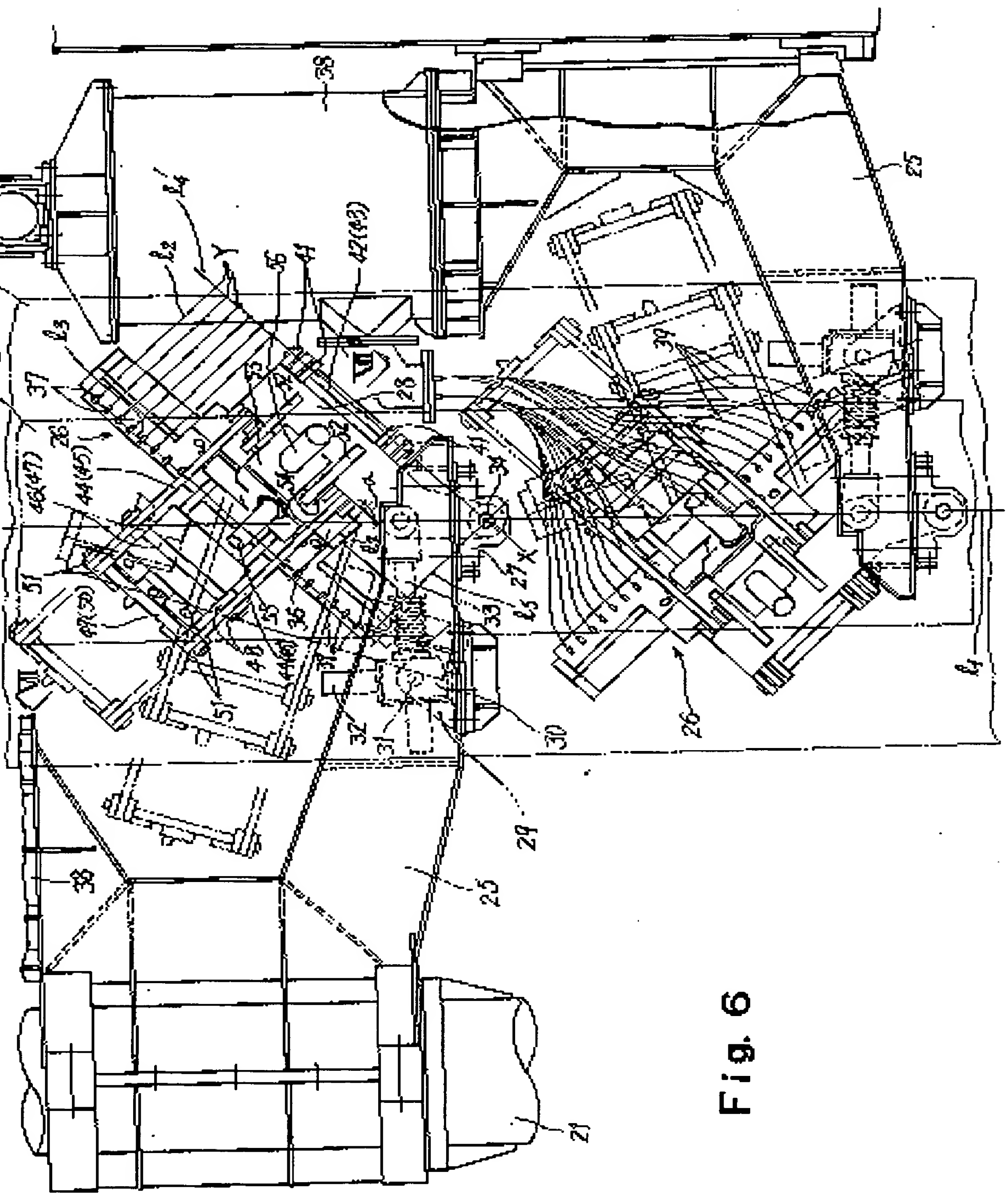


Fig. 6

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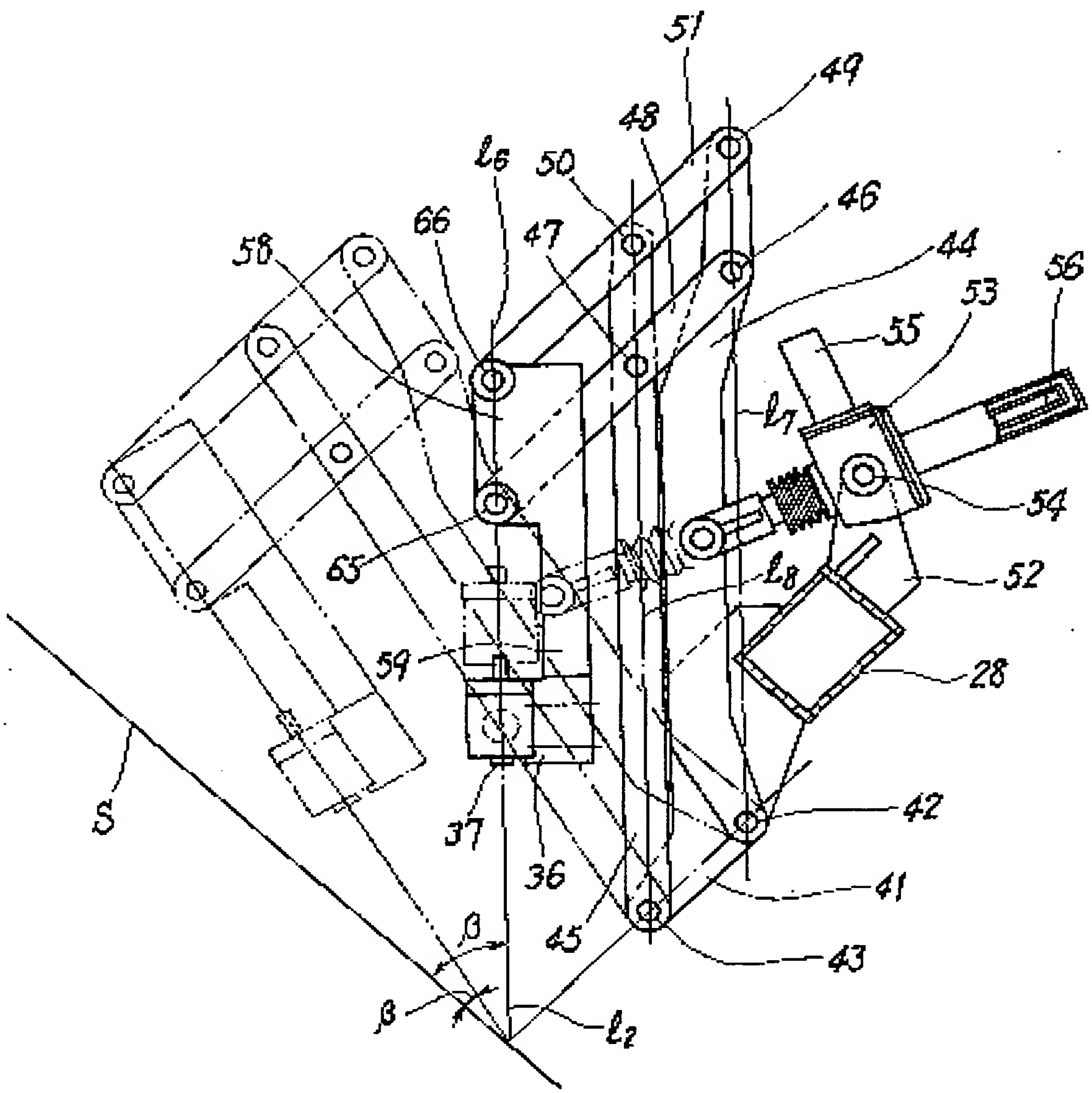
Fig. 7



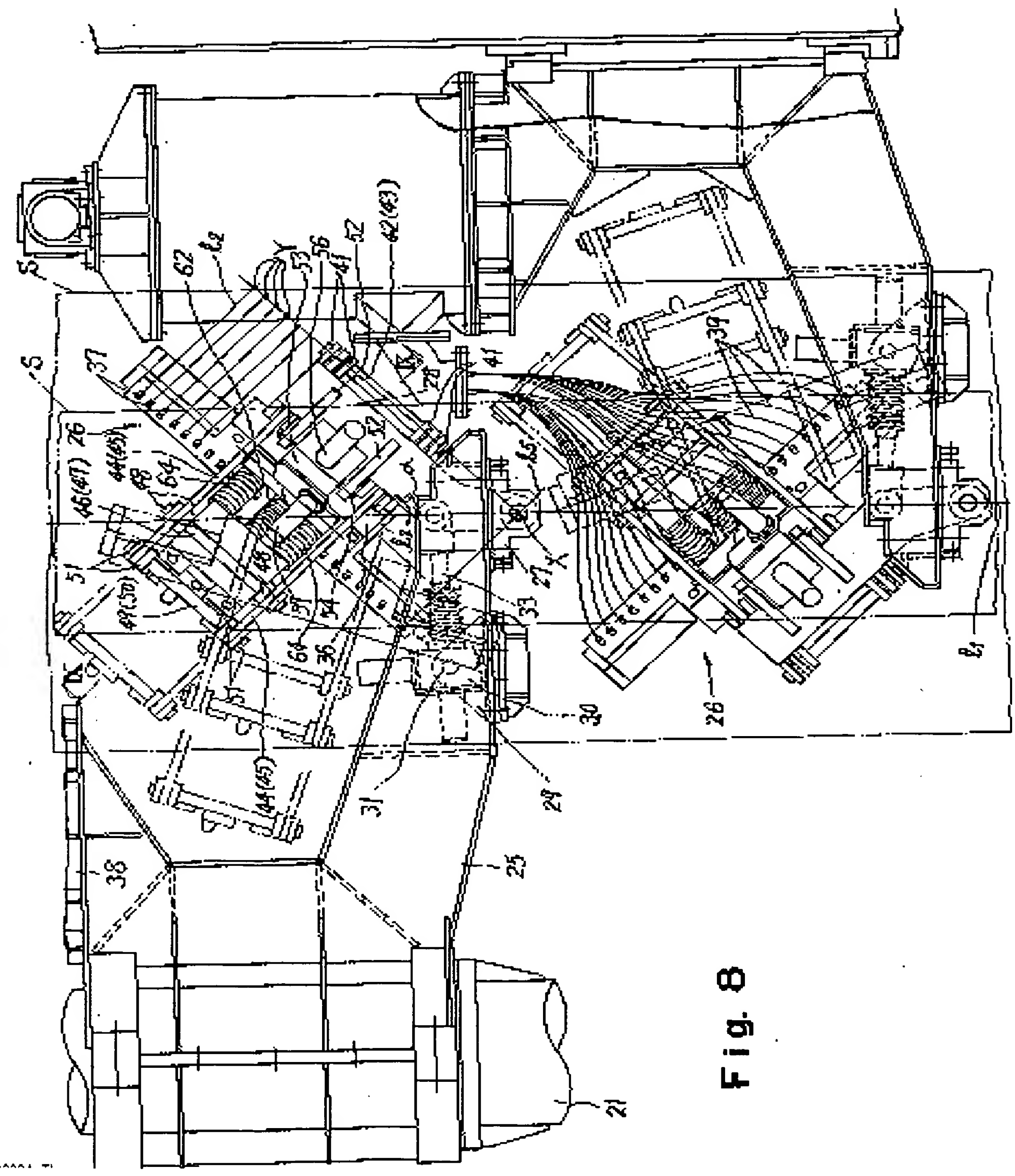


Fig. 8

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Fig. 9

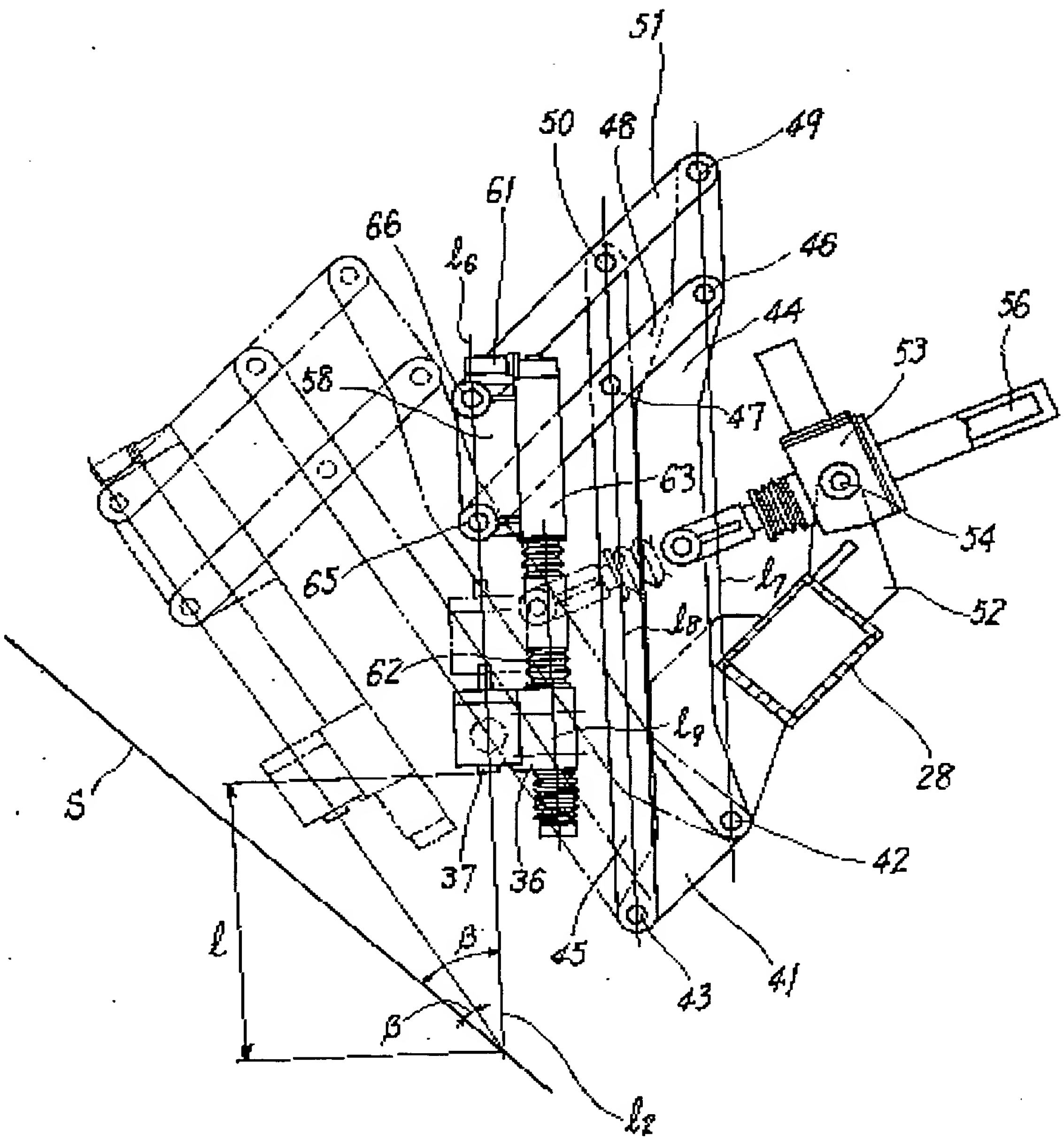

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Fig. 10

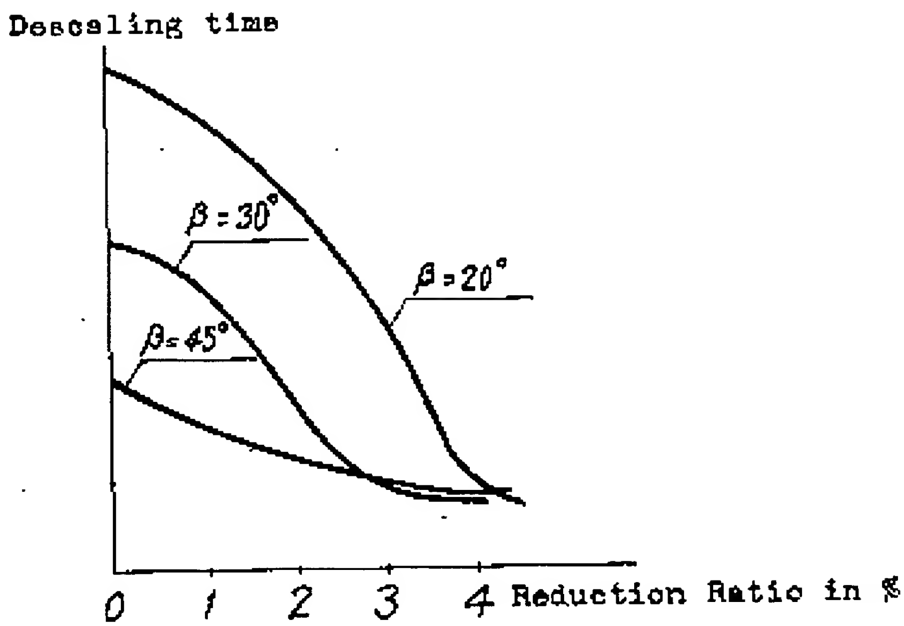

Fig. 11